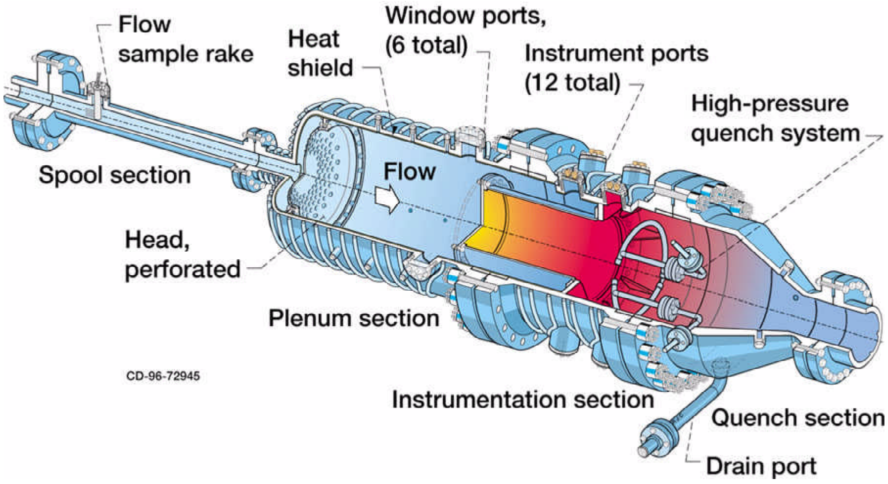
Optical Diagnosis of Gas Turbine Combustors Being Conducted

Researchers at the NASA Glenn Research Center, in collaboration with industry, are reducing gas turbine engine emissions by studying visually the air-fuel interactions and combustion processes in combustors (refs. 1 to 2). This is especially critical for next-generation engines that, in order to be more fuel-efficient, operate at higher temperatures and pressures than the current fleet engines.

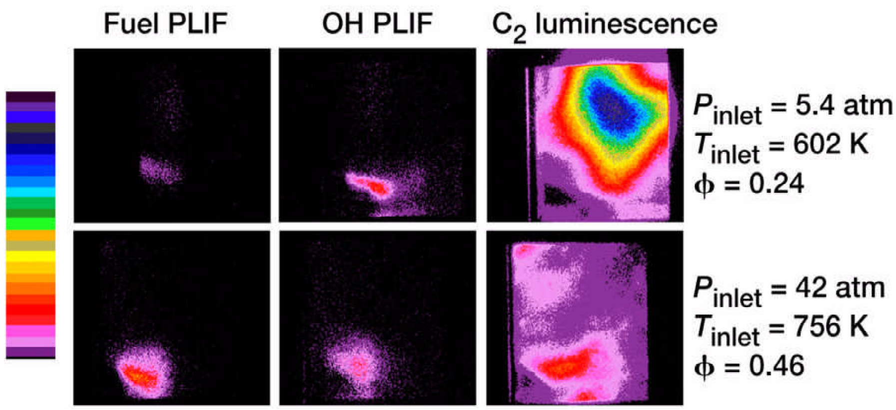
Optically based experiments were conducted in support of the Ultra-Efficient Engine Technology program in Glenn's unique, world-class, advanced subsonic combustion rig (ASCR) facility. The ASCR can supply air and jet fuel at the flow rates, temperatures, and pressures that simulate the conditions expected in the combustors of high-performance, civilian aircraft engines (ref. 3). In addition, this facility is large enough to support true sectors ("pie" slices of a full annular combustor). Sectors enable one to test true shapes rather than rectangular approximations of the actual hardware. Therefore, there is no compromise to actual engine geometry. The following figure shows a schematic drawing of the sector test stand. The test hardware is mounted just upstream of the instrumentation section. The test stand can accommodate hardware up to 0.76-m diameter by 1.2-m long; thus sectors or small full annular combustors can be examined in this facility.



ASCR sector combustor pressure shell. Flow passes from left to right. The inner vessel that contains the actual combustor hardware bolts onto the instrumentation section.

Planar (two-dimensional) imaging using laser-induced fluorescence and Mie scattering, chemiluminescence, and video imagery were obtained for a variety of engine cycle conditions. The hardware tested was a double annular sector (two adjacent fuel injectors aligned radially) representing approximately 15° of a full annular combustor. The next figure shows an example of the two-dimensional data obtained for this configuration. The fluorescence data show the location of fuel and hydroxyl radical (OH) along the centerline of the fuel injectors. The chemiluminescence data show C_2 within the total observable volume. The top row of this figure shows images obtained at an engine low-power condition, and the bottom row shows data from a higher power operating point. The data show distinctly the differences in flame structure between low-power and high-power engine conditions, in both location and amount of species produced (OH, C_2) or consumed (fuel).

The unique capability of the facility coupled with its optical accessibility helps to eliminate the need for high-pressure performance extrapolations. Tests such as described here have been used successfully to assess the performance of fuel-injection concepts and to modify those designs, if needed.



Comparisons of fuel planar laser-induced fluorescence (PLIF), OH PLIF, and C_2 chemiluminescence. Images are scaled per species. Conditions are as noted per row. Fuel-to-air equivalence ratio, f.

References

1. Hicks, Yolanda R.; Locke, Randy J.; and Anderson, Robert C.: Optical Measurement and Visualization in High-Pressure, High-Temperature, Aviation Gas Turbine Combustors. Optical Diagnostics for Industrial Applications, Neil A. Halliwell, ed., vol. 4076, 2000, pp. 66-77. (Also NASA/TM--2000-210377, http://gltrs.grc.nasa.gov)

2. Locke, R.J., et al.: Progress in Species and Flowfield Mapping in Advanced Liquid-Fueled Gas Turbine Combustors. AIAA Paper 2000-0774, 2000.

Glenn contacts: Dr. Yolanda R. Hicks, 216-433-3410, Yolanda.R.Hicks@grc.nasa.gov; and Robert C. Anderson, 216-433-3643, Robert.C.Anderson@grc.nasa.gov
Dynacs Engineering Company, Inc., contact: Dr. Randy J. Locke, 216-433-6110, Randy.J.Locke@grc.nasa.gov
Authors: Dr. Yolanda R. Hicks, Dr. Randy J. Locke, Robert C. Anderson, and Dr. Wilhelmus A. DeGroot
Headquarters program office: OAT
Programs/Projects: UEET